## ELECTRICAL PHENOMENA IN THE UPPER ATMOSPHERE.

By S. CHAPMAN.

[Abstracted from *Scientific American Supplement*, Sept. 27, 1919, p. 198, and Nov. 29, 1919, p. 323. See also note in *Nature* (London) June 19, 1919, p. 311.]

The electrical phenomena discussed in the paper are those arising in regions of the atmosphere at altitudes probably greater than 30 kilometers, as distinct from the ordinarily investigated phenomena of atmospheric electricity, which are confined to the troposphere and lower parts of the stratosphere.

Electrical phenomena in the upper atmosphere make themselves evident in two ways—by the production of luminosity, as in the case of the aurora, and by the variations which they cause in the earth's magnetic field. Auroral phenomena result from the injection, into the earth's atmosphere, of corpuscular radiations from the sun, the effects being associated, in large part, with particular regions of the sun's surface, e. g., sun spots. The sharp lower boundary frequently associated with auroral displays suggests a definite degree of penetration for the rays; and, the definiteness and magnitude of this penetration is well in harmony with the assumption that the rays are $\alpha$ rays. The assumption is further borne out by considerations of the magnitudes of the deflections which the rays must suffer, on account of their motion in the earth's magnetic field, in order to account for a radius of the auroral zones as large as 20 degrees, which is the radius found by actual measurement, and which is considerably greater than could be accounted for on the assumption that the radiation was of the $\beta$ ray type.

As regards magnetic phenomena, there is a direct part, arising from currents induced in the upper atmosphere, and an indirect part arising from the currents which these induce in the earth. The atmospheric currents are of two types—those associated with magnetically quiet days, and those productive of magnetic storms. The former result from the electromotive forces induced in the upper atmosphere, as a result of its motion in the earth's magnetic field, under atmospheric tidal action, and under the influence of temperature variations produced by the sun. The currents induced depend not merely upon the electromotive forces, but also upon the conductivity of the upper atmosphere itself. The latter is greater in the sun-lit portions than elsewhere, so that, superposed on the diurnal and seasonal variations which the tidal motion would produce, we have the changes arising from variations in the solar radiation received throughout the day and year. Considerations of the amount of ionization necessary to account for the effects, and of the degree of penetration which the radiation must have to enable it to escape from the sun's atmosphere, suggest that the radiation effective in this process is of the $\gamma$ ray type.

Disturbances of the magnetic-storm type are attributed to effects arising from the penetration of the outer layers of our atmosphere by the $\alpha$ rays responsible for the aurora. The view is expressed that, as the $\alpha$ rays enter the atmosphere, they cause a depression of the air as a result of loss of their momentum, and that this depression is followed by an upward motion resulting from electrostatic repulsion after the air has become charged. The downward motion of the air accompanying the depression, and the subsequent upward motion, both taking place across the earth's lines of magnetic force, give rise to induced currents; and, it is assumed that the magnetic fields of these induced currents are those which are found associated with so-called magnetic storms. The view adopted accounts for the reversal of the magnetic effect, which is found to take place soon after the commencement of a magnetic storm.—*W. F. G. Swann.*

## CLOUDINESS IN THE UNITED STATES.[1]

By Prof. R. DEC. WARD, Harvard University.

[Author's abstract.]

The available cloudiness charts include those of Teisserenc de Bort (1884), Greely (1891), Clark (1911), and Gläser (1912). Gläser has made the most complete study of the cloudiness and sunshine of the United States to date. A new chart of mean annual cloudiness is presented, based upon the latest and most complete data now available. These were prepared for the author by the U. S. Weather Bureau, and include observations through the year 1918. The new chart is broadly generalized, being designed to present the larger facts, and not to emphasize details. The distribution of mean annual cloudiness is described and explained, and the seasonal variations in cloudiness are considered. A series of curves is given showing the monthly amounts of cloudiness at groups of selected stations in various parts of the United States.

[1] Presented before American Meteorological Society, New York City, Jan. 3, 1920, to appear in *Geogr. Rev.*, 1919, vol. 8.

## THERMAL BELTS AND INVERSIONS OF TEMPERATURE IN THE NORTH CAROLINA MOUNTAIN REGION.[1]

By H. J. COX.

[Author's abstract.]

Observations were made by the U. S. Weather Bureau in the North Carolina mountain region from 1912 to 1916, inclusive, in cooperation with the North Carolina State Board of Agriculture, with the hope that so-called "thermal belts" might be more clearly defined.

Stations were installed at 16 places in the mountain region, distributed geographically and under varying conditions of topography, on valley floor, slope, and summit, there being 66 stations in all.

Inversion of temperature was observed on an average of three nights out of four, and the tendency toward inversion was so strong that the average minimum for the four-year period was found to be much higher at the summits than on the valley floor, and even at one place where the slope had a vertical height of 1,760 feet, this was true. Frequently inversions of 15 to 20 degrees F. were observed. The greatest was 31 degrees F. on Brown Mountain November 13, 1913, for a difference of elevation of 1,000 feet.

Inversions were noted under both anticyclonic and cyclonic conditions, in the latter case the temperature rising much more rapidly at the summit than at the base as the storm approached, warm winds of the lower levels being shut off by obstructing mountains and the cold air in the coves and valleys lower down being retained.

On the longest individual slope, 1,760 feet, the center of the thermal belt was usually at a point 1,200 to 1,300 feet above the valley floor, while on all short slopes (less than 1,100 feet) leading up to knobs, the highest minima were observed on the knobs themselves on radiation nights.

[1] Presented before joint meeting of Am. Meteorological Soc. and Assoc. of Am. Geographers, St. Louis, Mo., Dec. 31, 1919.

The minimum is always comparatively low on radiation nights where there is little if any warm free air available for interchange. This condition is most pronounced on the valley floor, but also quite evident in a sheltered cove, even though located on a slope. For the same reason the minima are lower on gradual slopes than on steep slopes, a given area on the latter having a much larger amount of warm free air facing it and at the same time not being so freely exposed to the sky as to suffer the same loss through radiation as the gentle slope.

When a slope has opposing mountains close by, the minima are lower, even though these mountains, in raising the sky line, affect the loss of heat through radiation.

Although the summit of a mountain is usually situated ideally for radiation purposes, the highest minimum is, nevertheless, noted at the very summit during inversion conditions, except when either its surroundings mass is great or its vertical height is great, a knob partaking largely of the temperature of the free air.

Where the mass is great a large number of radiating surfaces are present, which serve to reduce the temperature to a greater degree than if the summit were a mere knob, and in lowering the temperature in the vicinity of the summit the center of the thermal belt is also lowered.

The center of a thermal belt is lowest on a mountain slope where there is no opposing slope near by and the mass above in the region of the summit is great. The Tryon slope is a typical example of this condition, where the highest minimum is usually found at an altitude of 400 to 500 feet above the valley floor, there often being differences of 15 to 20 degrees F. between these points separated by only a few hundred feet.

On the other hand, the center of the thermal belt is high when the slope culminates in a knob, so that there is no considerable mass near the summit, and this is so whether there are opposing slopes or not.

When opposing slopes are present in the lower levels and there is a great mass above near the summit, the thermal belt is relatively narrow, as both these conditions tend toward lower night temperatures. Such a slope, as a whole, is a cold one. If, on the other hand, a slope is steep and there are no opposing slopes near by and no great mass near the summit, the entire side of the mountain is relatively warm during night inversions.

The temperature, ordinarily, on a night of inversion falls along the entire slope, as well as on the valley floor, but with increased elevation the fall is less and less, and the center of the belt rises steadily from nightfall to dawn.

Mountain breezes do not blow down the sides of a mountain from a mere knob, but where the mass is great, as at Altapass on the main Blue Ridge, or at Tryon, the breeze is frequently observed. The mass being freely exposed with its great surface, in fact an elevated plateau, becomes covered with a blanket of cold air on radiation nights and, if the prevailing wind is favorable, after a time this cold air rushes down the side of a mountain in a more or less waterlike flow, being mechanically warmed in its descent, but nevertheless serving to lower the temperature, at least for a time, on the slope, while raising it in the valley below where the temperature has already fallen to a low point. If the wind is blowing from an unfavorable quarter, the mountain breeze does not develop, even though other favorable conditions are present.

Inversions are most frequent during the months of May and November, when the weather conditions are usually settled in the mountain region, long periods of fair weather then prevailing. They are somewhat more pronounced in the latter month because of the greater length of the night, the thermal belt rising as the length of night increases.

Inversions are almost as frequent during the summer months, but the range is small. In the winter months, when they are much less frequent, the range is great. During a period of fair weather the range of inversion increases steadily up to about the fifth night, the peak being reached at that time. Thereafter increasing vapor and impurities in the form of dust and smoke interfere with radiation. The range of inversion depends decidedly upon relative and absolute humidity. The vapor pressure controls the degree of inversion in that the loss of heat by radiation through moist air is small, while through dry air it is large.

The lowest absolute and average minima during the entire research were found in a small frost pocket at Highlands, but the lowest minimum considering altitude above sea level was found in a wide valley floor of the French Broad River near Blantyre.

The higher temperatures on the slopes and certain summits in the Carolina mountain region are favorable for fruit growing in so far as the absence of frost is concerned, as compared with the valley floors, but considerable injury often occurs from freezes in the winter and early spring in the upper and middle levels after protracted heated periods and growing weather which had served to swell the buds.

## THE EFFECT OF A "LID" ON THE TEMPERATURE AND TRANSPARENCY OF THE LOWER AIR.[1]

By JACQUES W. REDWAY, Mount Vernon, N. Y.

The word "lid" was coined by Sir Napier Shaw to describe a condition in the lower atmosphere in which a warm layer overlying a cooler one acts as a limiting plane or lid to the convectional circulation of the underlying air. If the warm layer is in motion relative to the air below, as it usually is, the lid may be turbulent. The convectional currents of warm more or less hazy air rising from the surface stop and spread horizontally on reaching the lid. Thus, the haziness is confined and the amount of air to be warmed by the earth's surface is limited. When the haziness is largely due to smoke, the aviator is more concerned than the mariner, for the air is clearest near the earth's surface; but when the haziness is due mostly to moisture conditions of the air, the haze is likely to be densest at the earth's surface, unless clouds tend to form at the lid. The presence of a lid makes the temperature at Mount Vernon about the same as that in New York City (Whitehall Building). Without a lid, however, the range at Mount Vernon is several degrees greater than at New York.—*C. F. B.*

[1] Presented before the American Meteorological Society at New York Jan. 3, 1920. This paper is a rearrangement of a part of a chapter on the "Principles of the transparency of the air governing visibility," in one of the author's books.